Comparison (of shipborne radiometers) with other in situ measurements

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Validation uncertainty budget

- Satellite (σ_1)
  - Varies pixel by pixel
- Reference (σ_2)
  - Generally unknown; Estimate of *O*(0.1 K) for GTMBA moorings and radiometers; *O*(0.2 K) for drifters; negligible for Argo
- Geophysical: spatial – surface (σ_3)
  - Systematic for single match-up; pseudo-random for large dataset
  - Can be reduced through pixel averaging (e.g. sample 11 by 11 instead of 1 by 1)
  - Includes uncertainty in geolocation (may be systematic even for large numbers)
- Geophysical: spatial – depth (σ_4)
  - Systematic for single match-up for different depths; pseudo-random for large dataset at different depths (with diurnal & skin model)
- Geophysical: temporal (σ_5)
  - Systematic for single match-up; may be reduced for large dataset (if match-up window small enough)
  - Can be reduced with diurnal & skin model

$$\sigma_{Total} = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \sigma_4^2 + \sigma_5^2}$$

Reference datasets

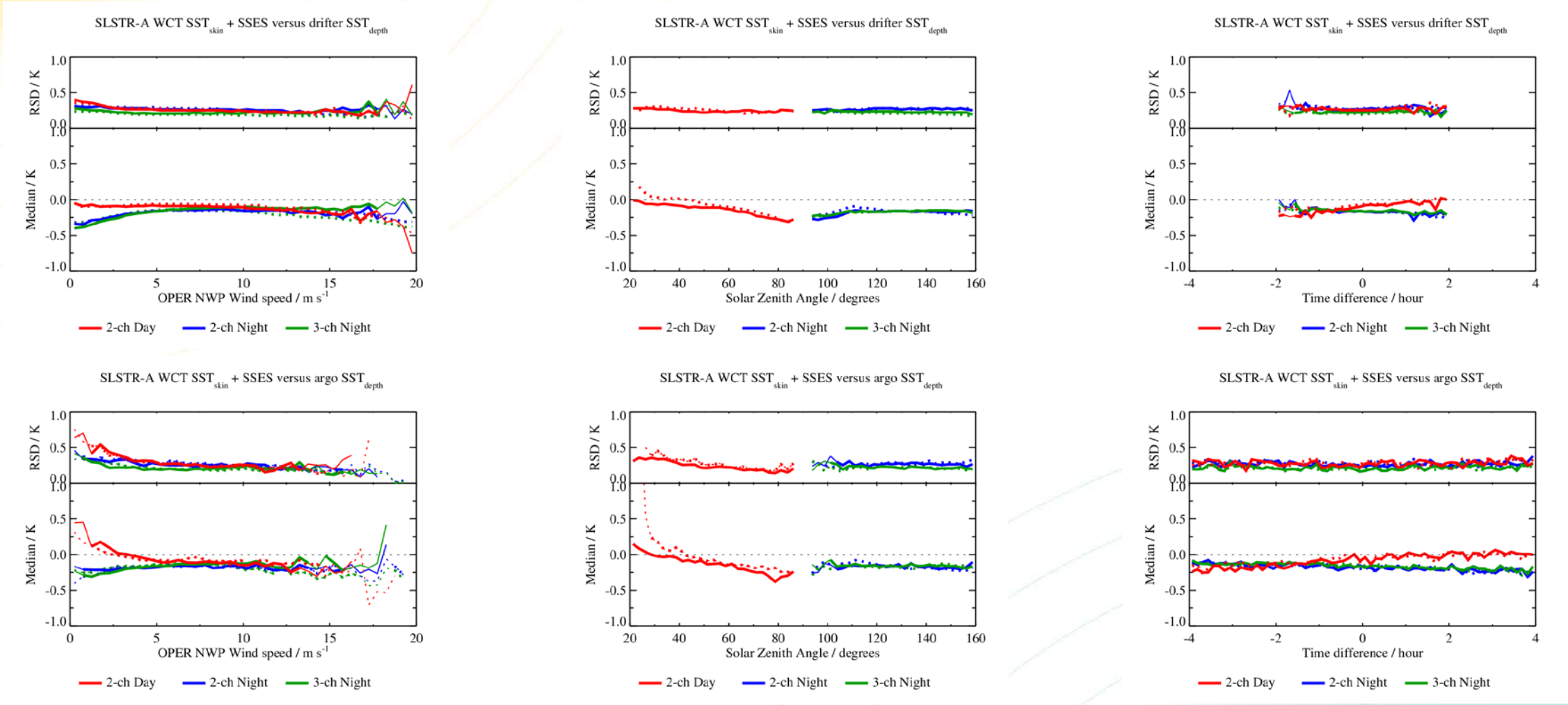
- Ship-borne radiometers
  - Traceable to SI; SST-skin; very-high accuracy; very-poor coverage
- Drifting buoys
  - Unknown calibration; global data; SST-depth; good coverage in recent ~decade
- Argo near-surface
  - Global; acceptable sampling; very-low uncertainty (calibration method to be analysed)
- GTMBA
  - Better calibration; SST-1m; acceptable coverage (influenced by data collection);
- VOS and VOSclim
  - Generally poor coverage; very high uncertainty on single sample
- Everything else…

Uncertainty estimates for various reference datasets

Data type	Year	Coverage	SST*	Uncertainty
Ship-borne IR radiometers	1998 -	Repeated tracks in the Caribbean Sea, North Atlantic Ocean, North Pacific Ocean, and the Bay of Biscay; episodic deployments elsewhere in the world's oceans.	SSTskin	0.10 K
Argo floats	2000 -	Global# from ~ 2004 onwards.	SST-5m	0.05 K
GTMBA	1979 -	Tropical Pacific Ocean array completed in 1998; tropical Atlantic and Indian Ocean arrays installed later.	SST-1m	0.10 K
Drifting buoys	1991 -	Global# from ~ 2000 onwards.	SST-20cm	0.20 K

Validation results – “raw” drifter and Argo

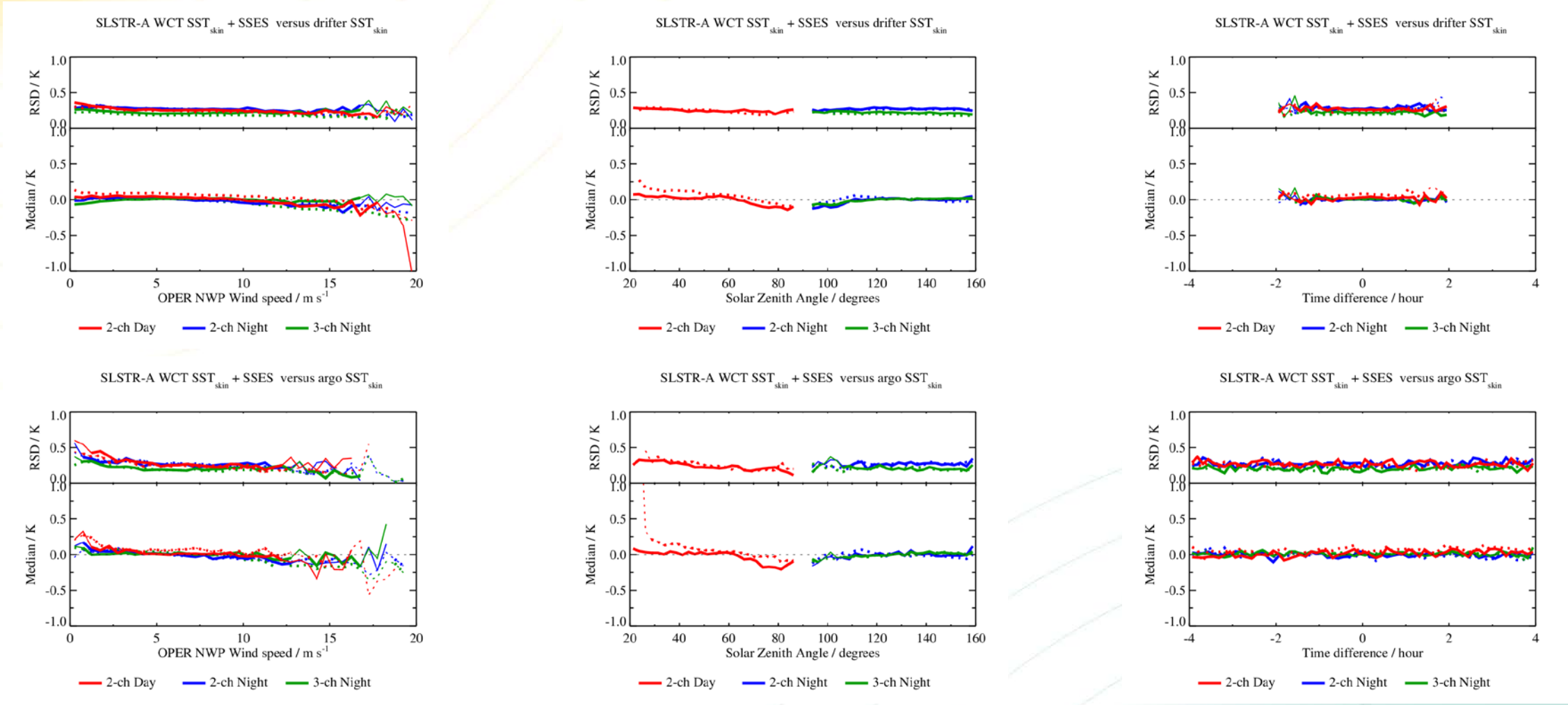
Drifter matchups (top row) and Argo matchups (bottom row)



Colours show number of channels; solid lines indicate dual-view; dashed lines indicate nadir-only.

Validation results – drifter and Argo with FKC adjustments

Drifter matchups (top row) and Argo matchups (bottom row)

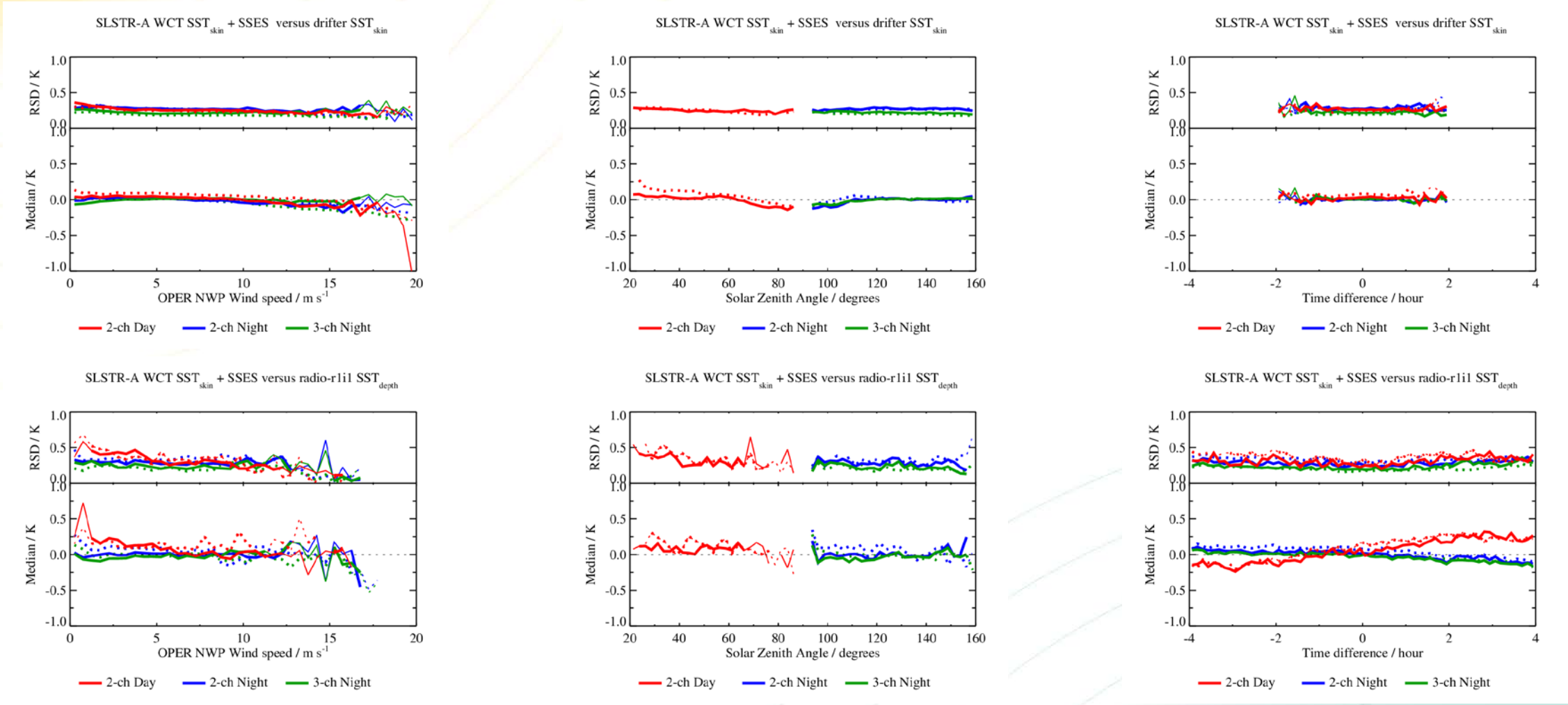


Colours show number of channels; solid lines indicate dual-view; dashed lines indicate nadir-only.

FKC = Combined Fairall & Kantha/Clayson skin-effect/diurnal-variability model driven by ERA-interim fluxes

Validation results – Compare drifter/FKC and radiometer

Drifter matchups (top row) and radiometer matchups (bottom row)

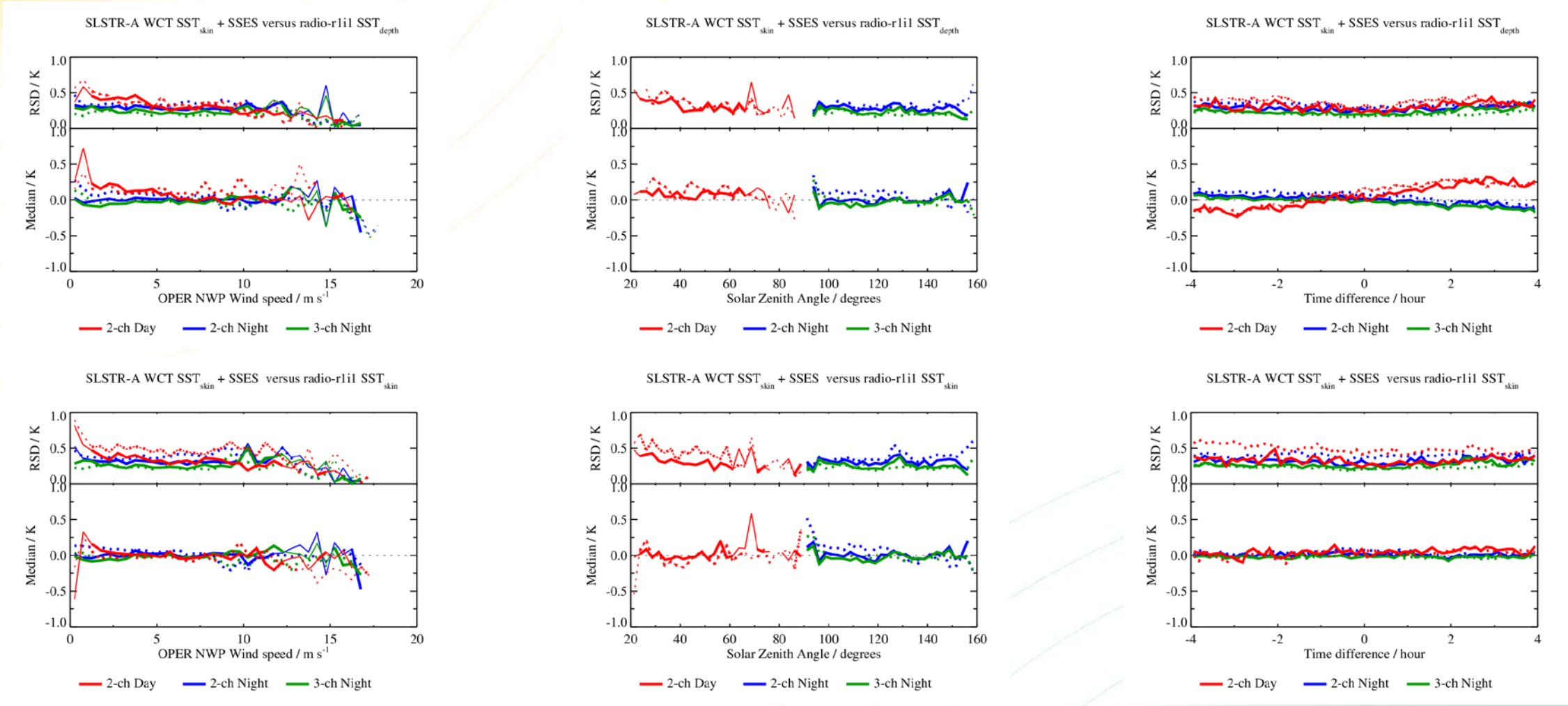


Colours show number of channels; solid lines indicate dual-view; dashed lines indicate nadir-only.

Radiometer data provided by ISFRN (http://www.shipborne-radiometer.org/); FKC = Combined Fairall & Kantha/Clayson skin-effect/diurnal-variability model driven by ERA-interim fluxes

Validation results – Compare radiometer and radiometer/FKC

Radiometer matchups (top row) and radiometer/FKC matchups (bottom row)

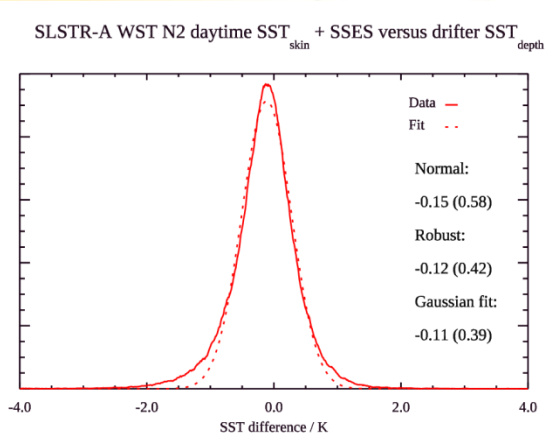


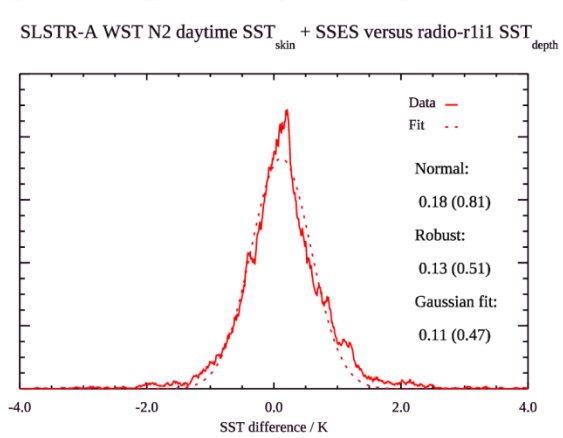
Colours show number of channels; solid lines indicate dual-view; dashed lines indicate nadir-only.

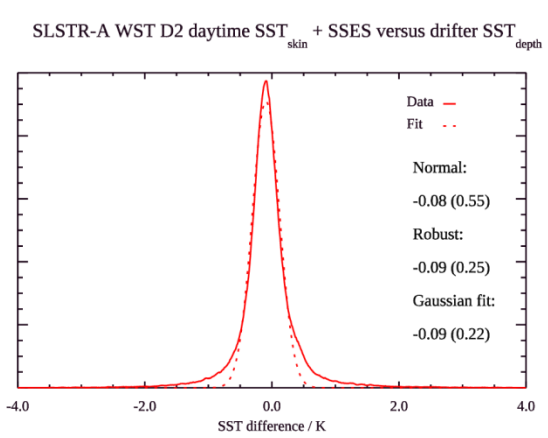
Radiometer data provided by ISFRN (http://www.shipborne-radiometer.org/); FKC = Combined Fairall & Kantha/Clayson skin-effect/diurnal-variability model driven by ERA-interim fluxes

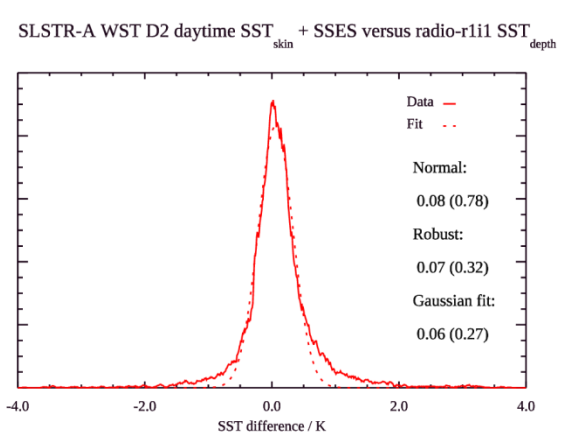
Validation results – Histograms & Uncertainty Validation

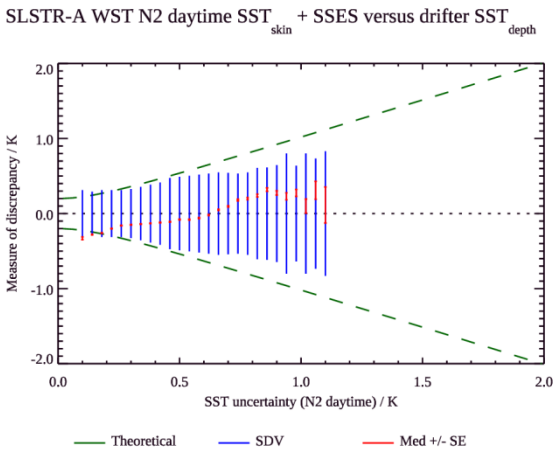
Drifter / radiometer N2 matchups (LHS) and D2 matchups (RHS)

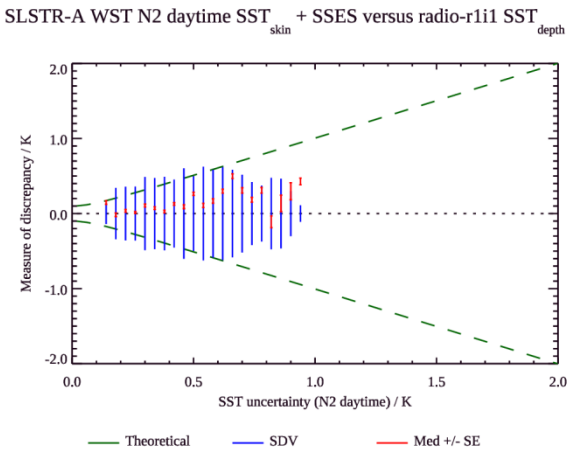


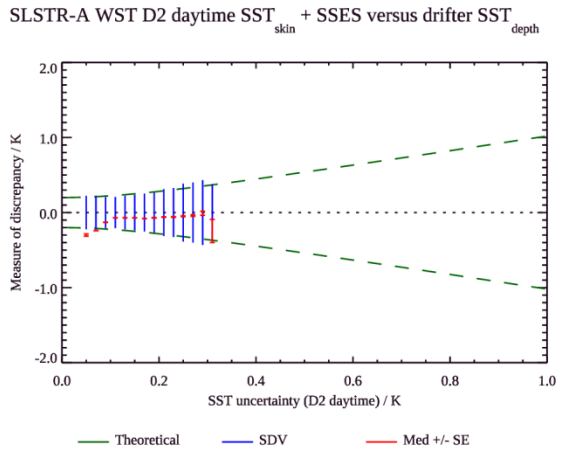


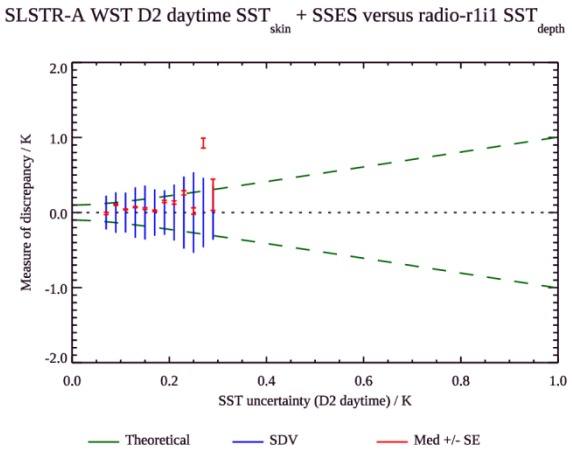










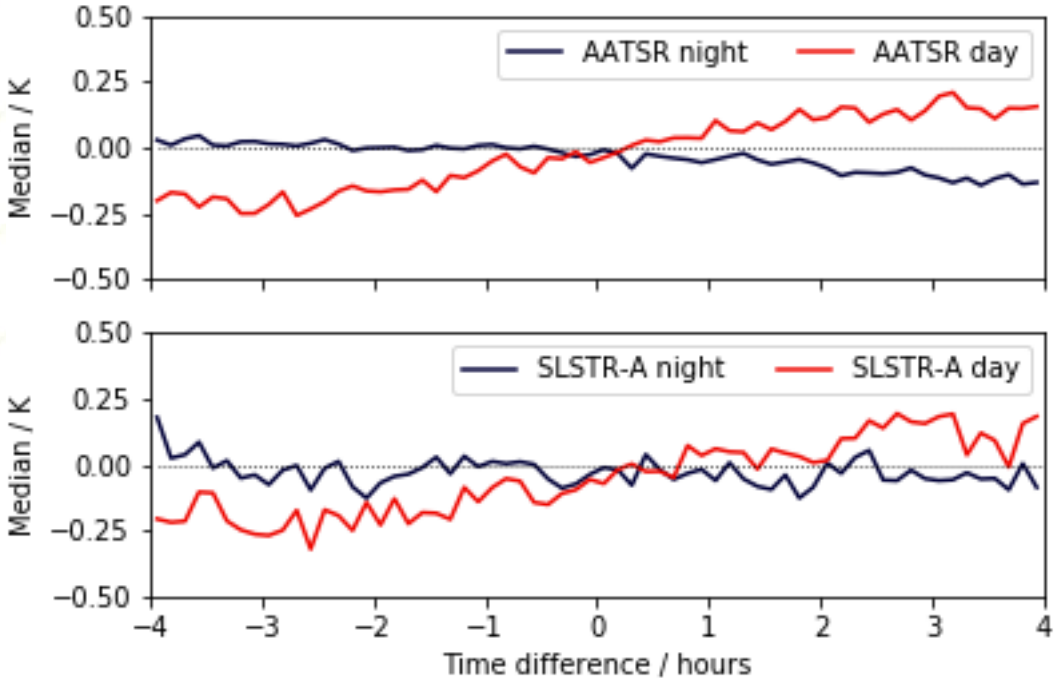


Radiometer data provided by ISFRN (http://www.shipborne-radiometer.org/)

Summary

- Validating satellite SST retrievals using reference data sets has many sources of error that cannot easily be corrected
  - By considering each term we end up with a validation uncertainty budget
- We can minimise the magnitude of certain effects using our knowledge of variability in upper ocean temperature
  - We should always be retrieving SST_{skin} from IR radiometers and using the physics to compare to reference data at different depths
- Radiometers provide an essential source of data for satellite SST_{skin} validation
  - Resulting statistics are generally noisier than for other primary in situ types
- Either uncertainty model is wrong or radiometer “measurement” uncertainty is higher than 0.1 K
  - Results might not yet be statistically significant

Comparison of AATSR and SLSTR: Bridging the gap…



Merchant, C.J.; Block, T.; Corlett, G.K.; Embury, O.; Mittaz, J.P.D.; Mollard, J.D.P. Harmonization of Space-Borne Infra-Red Sensors Measuring Sea Surface Temperature. *Remote Sens.* **2020**, *12*, 1048